nantly volcanic rock section. The age of the crust in the vicinity of the Minnesota hole is anticipated to be as old as 3.6 Ga, with a possible 1.8-Ga overprint, and the crustal age in northern Kansas is 1.65 Ga (Cover), providing a useful age contrast of mantle magma reservoirs. It is anticipated with core holes of the order of 4 km in both regions that all primary and many secondary scientific objectives can be achieved. Specific drilling sites in both regions can be selected in a limited span of time with analysis of existing data and consideration of surface logistical factors.

The eastern Northern Peninsula of Michigan is a particularly attractive site for sampling by shallow drilling of a succession of dipping basaltic volcanic rocks that attain a thickness of 20 km in nearby eastern Lake Superior. Additional geophysical observations and analysis are required to specify the location of the transect and holes on the transect.

Conclusion

Two closely related primary objectives for MCR drilling emerged from and were strongly endorsed by participants at the Duluth workshop, and drilling sites were subsequently proposed by working groups. Additional studies will be required for precisely locating the holes, as well as for siting the eastern northern Michigan transect. While many of the workshop participants, and others subsequently, have expressed specific interests in participating in the related research, we anticipate this drilling program will be open to competitive proposals at an appropriate stage. Reader's comments on the primary objectives, the proposed drilling sites, or other aspects of the MCR drilling program are welcome and should be sent to Co-Chairs of the Steering Committee, W. J. Hinze, Department of Earth and Atmospheric Sciences, Purdue University, West Lafayette, IN 47907 and W. C. Kelly, Department of Geological Sciences, University of Michigan, Ann Arbor, MI 48109-1063.

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This article was prepared by W. J. Hinze and W. C. Kelly, on behalf of the participants of the Midcontinent Rift System Scientific Drilling Workshop, Duluth, Minn.

Richard P. Feynman 1918–1988

PAGES 1649, 1657

Richard Feynman, simply put, was a genius. His quick wit and uncommon grasp of physics meant that any research area he encountered, he quickly mastered. Despite the fact that his own area of research was not geophysics, his life and work influenced almost all of us.

Virtually every physics graduate student who started in the mid 60s or later was exposed to his *Lectures on Physics*, either by having them as a text for a course or by using them (as I did) to bone up for oral qualifying exams. Feynman diagrams appear in nearly every modern quantum mechanics textbook and are featured in his official Caltech portrait, which illustrates this article.

The portrait also embodies the other reason that he holds such fascination even to those who never met him. He was the kind of scientist each of us in our heart of hearts would want to be—incredibly talented, yet full of childlike excitement in the quest for knowledge. The monk-like habit, reminiscent of Yoda, the open lock dangling from his finger—symbolizing to my mind not only his famous pastime of lock-picking but also unlocking the secrets of the universe—and the wry smile all add up to a portrait of someone you'd just love to know.

We all laughed at his fascinating, funny autobiography *Surely You're Joking, Mr. Feynman*; we all smirked at his elegant demonstration of the brittleness of the shuttle O-ring seal when he tapped it after chilling it in his glass of ice water; and we all cried inside when he died. The following remembrances, from a few of the AGU members who did know Feynman personally, are offered here as vignettes of one of the most fascinating people of our lifetime. The first piece is by his sister, Joan Feynman, who explains why Feynman didn't do research in auroral physics. The others are by Thomas Gold, Gerald Wasserburg, Neil Sheeley, and Syun-Ichi Akasofu. Finally, I would like to acknowledge Rob Wolff (currently at Apple Computer), whose own remembrances in *Physics Today* (1988) inspired me to collect these memories. Like the Caltech students the day after his death, we hold the banner "WE LOVE YOU, DICK!!"

Patricia H. Reiff
Eos Editor for Solar-Planetary Relationships
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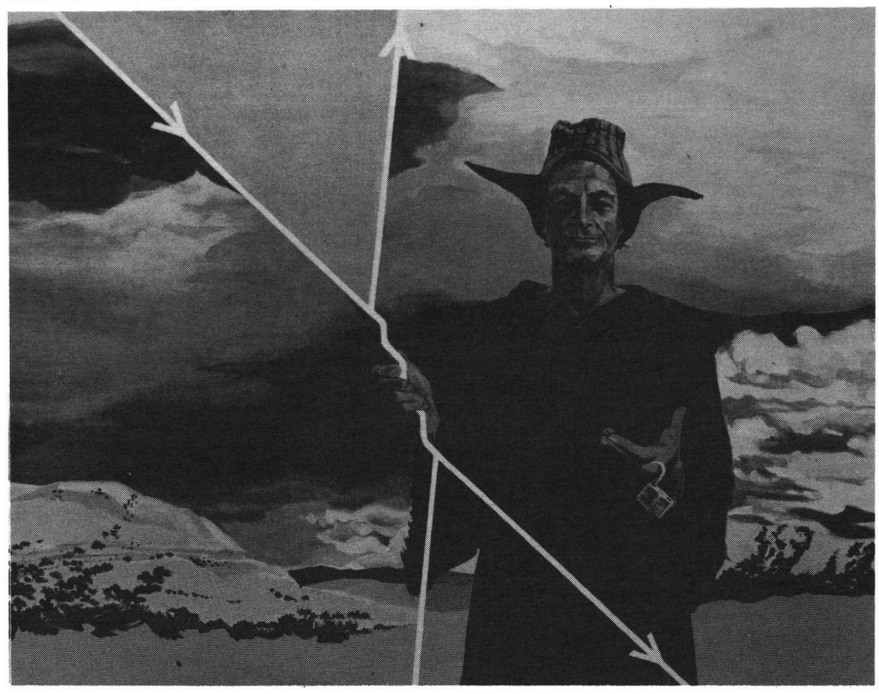


The official Caltech portrait of Richard Feynman shows the physicist holding an open lock and a Feynman diagram. The background is the landscape around Los Alamos National Laboratory in New Mexico. He wears a costume (originally made for a party) from the Ladakh region of the Indian Himalaya Mountains. Through Feynman's efforts stemming from his deep interest in that region, an exhibition from the U.S.S.R., "Nomads: Masters of the Eurasian Steppe," will be at the Natural History Museum of Los Angeles County (Calif.), February–April 1989. From a color painting by Sylvia Posner.

Relinquishing the Aurora

When Pat Reiff told me of her plans for a group of letters about my brother, Richard Feynman, I decided to make a contribution, and since it's about Feynman, I'll tell a story.

My brother and I grew up on Long Island in New York State in a well-run household where things happened when they were supposed to happen. In particular, little children went to bed on time and stayed there until morning.

One night, however, when I was 3 or 4 and Richard was 12 or 13, there was a break in the routine. It was late, but Richard was shaking me awake. He explained that our parents had given him permission to wake me because there was something wonderful he wanted me to see. He took me by the hand and we walked the 2 blocks to the nearby golf course, away from all street lights. "Look up," he said, and there in the sky were the flickering lights of my first aurora.

Years later, when I already had my Ph.D. in solid-state physics, the space age began and I was lucky enough to be hired at Lamont-Doherty Geological Observatory. I had moved to Rockland County, New York, and had quit work to take care of my 2 small sons, as was customary in those days. It was customary but intolerable, and it soon became clear that the choice for my children was a part-time mother or full-time witch.

I didn't know much about getting a job, so I carefully filled out an application and left it at the reception desk at Lamont. About a week later, I got a call from them. Three people wanted to interview me. One of them was Jim Heirtzler, who told me he was working on rapid variations of the Earth's magnetic field. "Oh," I said, "Does it vary?" For some reason, known only to him, Jim offered me a job and I took it.

Now there I was, working in a field with wonderful problems about which almost nothing was known. It was and is great fun and an intriguing puzzle. I wanted to tell my brother about it because it was so exciting. But wait a minute! We have all had the experience of working hard on a difficult puzzle and, just when you think you're making progress, some puzzle expert comes along and finishes it for you when you're not looking. Clearly Richard was a great expert in physics puzzles. Was he going to give me the answers whenever things got to be exciting? Horrors!

And so I offered him an agreement, half in earnest and half joking. I suggested we divide up all of physics and astronomy. I would take the aurora and he could have the rest of the universe. He agreed and never broke the agreement, although it was always considered a joke by both of us. He followed planetology and all the rest of geophysics with great interest, but he kept his distance from solar-terrestrial relations and the aurora.

I'd like to thank Richard Feynman, my brother, for showing me the aurora and then for letting me have the great fun of puzzling over it.

Joan Feynman
Jet Propulsion Laboratory
Pasadena, Calif.

A Genius with Puzzles

"When you get to Pasadena, you absolutely must meet Feynman," some of my colleagues in Cambridge told me in 1955 as I was preparing a trip to the U.S. I corresponded with him, and he suggested that we meet for breakfast in a pancake restaurant. We were both into intellectual teasers and puzzles, and getting acquainted was to exchange all the the ones we knew. Of course, he had heard most of mine before, or sufficiently similar ones, so they presented no challenge. Equally, he presented his with the words, "You must know this one," but as with telling old jokes, it is still entertaining among puzzle addicts.

I had invented one myself just shortly before, a rather clever and tricky one, I thought, which none of the Cambridge addicts had been able to do on the spot. He could not have heard that one. As I explained the puzzle, he kept completing my sentences. When the number 26 came up, he said, "27 minus 1, so you can't do it with 27." Before I came to the end, to pose the question, he had already thought out the elegant solution, and with that had re-invented the puzzle.

We sat in that restaurant over lunch and, in fact, until evening, enjoying puzzles and subtle problems from the physical sciences. He clearly had thought through a lot of subjects, even much that was quite far removed from his own major activities. Even if something was new to him, it did not take him long to explain it, especially if there was some particular difficulty. His speed was breathtaking!

Many years later, in my house in Ithaca, we got him to discuss his ability with combination locks on safes. (Feynman wrote "I have been here" in a super-secret safe in Los Alamos, just to see whether the owner would own up to Security over the infringement!) My five-year-old daughter brought down her little toy safe with a 3-figure combination lock. "Can you do that one?" she asked.

That would have been quite a problem, if he had really to go through a few hundred combinations. To avoid embarrassment, I tried to divert to another subject. But no: He shook it a little, turned the knob and listened—just as you see in the movies—and in a moment it was open! Never mind the 5-figure lock in Los Alamos, in the eyes of my daughter he really was a genuine safe-cracker.

It is said of some people who are modest, that they have a lot to be modest about. Feynman was not modest, but he had more to be immodest about than anyone I have ever come across. I once had occasion to explain to him a subtle point about planetary atmospheres: that if they are very opaque, they will develop the adiabatic temperature gradient even if heated only from above in the uppermost layers, and the bottom will therefore get very hot without doing any damage to the second law of thermodynamics. He said, "Gee! I had never thought of that." Why should he have? It was not near any of his subjects; but it was subtle, and as with puzzles, it was his domain.

Once, in his house, his son remarked to him, "My teacher says you must be an absolute genius." I assume he had helped with some homework and swindled in some clever trick. That the boy was unaware of the truth

of the remark is fine; but did the teacher really not know about whom he was talking? I said to the boy, "Maybe your teacher is right." He replied, "Naaa," and shook his head. To an 11-year old, a father is a father and not a genius!

But to many of us who knew him, he remains a genius. Not a distant, impenetrable scientific genius as so often portrayed in fiction, but that bright Brooklyn boy, immensely proud of his achievements, yet retaining his brim-full measure of good humor, wit and charm. How marvellous that such an intellect and that personality could meet together in one person!

Thomas Gold
Cornell University, Ithaca, N.Y.

A Floating Spirit

When I came to Caltech at the tender age of 27, Dick Feynman was, by my standards at the time, an older man—a kind of sage. He was 35. I was considered as old by Murray Gell-Mann, who came at the same time. There was a small parking lot by Culbertson Hall, where the South Mudd Building now is. The parking places for Dick, Murray, Fritz Zwicky and myself were close to each other and we became parking lot buddies. We would chat while going to our offices or back to our cars in the evening.

The discussions with Dick were always special. He would tell me about something that he was doing and then would want to know (really want to know) what I was about. When I would try to explain some research idea or program, Dick would say, "Don't hand me that crap. Tell me what you are really doing." This was the best education I ever got! Dick didn't want to hear jargon or an obscure description but rather a concise, clear and objective outline in which the physical principles, facts and problems were evident. It was obvious that Dick knew the laws of nature (not counting chemistry!) far better than I, and could grasp the concepts at a foot a nanosecond. My charge was to eliminate the lab jargon and the confusion. His intense interest and delight in all sorts of science helped spark me. By the time I had explained something to Dick's satisfaction, I knew better what I was doing.

This type of conversation continued over the years and was parking lot invariant. Sometimes I think it was the main reason for my staying at Caltech. When I explain to students how to write a paper or give a talk, I always remember those experiences and tell them, "Imagine that you are talking to someone like Dick Feynman, explain the problem and approach assuming that your listeners or readers are incredibly smart and know the laws, but are also incredibly ignorant. Don't burden them with baloney, but with the real essentials of logic, fact and beauty."

I remember Dick coming up to me while I was in a hurry to go somewhere. He was in a state of excitement because some undergraduate in physics had come up with a clever and new solution to a difficult problem. He was beaming, and explained it all to me in some detail. I remember standing halfway on the steps, impatient at the interruption. Now, I don't remember what important event I was going to, but I do remember the wonderful conversation.

When Dick was starting Feynman physics (a sort of freshman course for post graduates and professors), he found out that I was teaching a course in mineralogy and came for extensive visits. I would explain crystallographic symmetry groups and crystal structure and optics, and then provide him with samples for the class. When it was over, he presented me with a beautiful quartz crystal with oriented fluid inclusions, which he picked up in Brazil. Naturally, he would not give it to me until I could explain it to him. It is, of course, still in my office.

Besides the crystal, Dick had picked up bongo drums in Brazil. One night, at a party in my house, Dick saw a pair of bongos that I had gotten in Tijuana. "Do you play?" he asked. "A bit," I said. I played. Then he took them and he played. I never played bongos again.

When the Lunatic spectrometer was just being finished, we had otained the Colomera iron meteorite from Spain after enormous complications. It was the first iron meteorite ever to be internally dated. It sat on the floor. When Dick came for a visit, we would both lie down on the floor on either side so that we could discuss the peculiar silicate inclusions in the iron-nickel and talk about how planets form.

About ten years ago, when Dimitri Papanastassiou and I were discovering the wonderful isotopic anomalies in meteorites, worrying about the quality of the data and their meaning, Dick was at my house and we went over the exciting results. The phone would ring and Dimitri would tell me some new and wild data. I would scribble the results on the board and talk excitedly with Dick: Which kind of star? Where can you make these nuclei? After a bit, he said, "You aren't happy." I replied, "I don't understand the meaning of these results." Dick responded, "That is the best time, when you find something exciting and fundamental and you don't understand it. Then you have really done something important."

Dick was a kind of floating spirit who was, for the most part, disengaged from the usual mundane activities. On some occasions, he would plunge down to test truth or analyze a problem. His interests in education were deep. There is no doubt that his service on the California State Textbook Commission was of substantial importance on the state, and even national, level. These occasional plunges by Dick, such as the textbook commission and the investigation of the *Challenger* disaster, were great symbols to us all.

G. J. Wasserburg
California Institute of Technology, Pasadena, Calif.

Learning with Feynman

I first encountered Richard Feynman one Sunday afternoon in September 1956 at a so-called "freshman mixer" in the Dabney Hall of Humanities at Caltech. It was a social function with girls from neighboring schools, a dance band, and refreshments. During an intermission, people began to gather in the patio outside, but the crowd was too large for me to see why. It turned out that Feynman was playing the bongo drums with the infectious enjoyment now captured by the photograph in the preface of his *Lectures on Physics*.

He was even more popular as a speaker. In the early 1960s, he gave a talk on "gravity" at a Thursday afternoon Caltech physics department seminar. As people began to gather in the physics library for tea and cookies before the lecture, some of us appreciated that seats would be scarce and quietly slipped away to the lecture hall upstairs. As we waited in our seats, we watched people stream in to fill the remaining seats, then to sit on the steps in the aisles, then to stand inside the door, and finally to stand outside the door, where they could at least hear what was being said. Professor Matt Sands came in just before lecture time and sat on an overturned wastebasket. These people were not just physics students and faculty; they were secretaries, machinists, lab assistants, administrators, non-physics faculty and students, as well as scientists and engineers from the Jet Propulsion Laboratory and other off-campus locations. Feynman showed a slide containing the gravitational field equations in covariant tensor form and remarked that he had not expected such a diverse audience and that we could simply regard this slide to be the "equations of gravity in secret form."

I think that his widespread popularity reflects the fact that he did not talk down to people, but challenged himself to understand the world from their points of view. This method of analyzing a problem in several different ways seemed to underlie his teaching, as I found during the 1957–1958 academic year in his section of Introductory Electricity and Magnetism. He scorned the use of encyclopedic knowledge as a means of problem solving. The proper approach to a problem was definitely not to reply that "the solution has been worked out on page such-and-such of Morse and Feshbach." Rather, Feynman liked students to admit they did not understand something, and he joined them in the game of finding several different ways of understanding it. Conversely, we gained confidence from the many times that he said that he didn't know something, and we thereby received a kind of calibration of what one ought to know.

In Feynman's section, we used the same text and took the same final exam as students in the other sections, but we didn't have formal homework. As exam time drew closer, we began to worry that we had not learned enough of the conventional material, and we spent quite a bit of time reading the chapters and asking Feynman questions. In effect, he was helping us "cram" for the final and, as one might expect with such a tutor, we all did very well.

The last time I saw Feynman was in his office in East Bridge soon after he had received the Nobel Prize. (I think it was in the fall of 1965.) He had just opened a package that someone had given him in honor of receiving the prize. It contained a rear view mirror with a card saying, in effect, "so you can remember your friends." He thought that was very funny. I remember thinking there are lots of Nobel prizewinners, but there is only one Richard P. Feynman.

I don't know if there is a place called Heaven, but if there is, it must be a much more exciting place now with Richard Feynman

asking countless questions in an attempt to understand his new world.

Neil R. Sheeley, Jr.
Naval Research Laboratory, Washington, D.C.

A Visit from Feynman

Professor Feynman unexpectedly dropped in my office at the Geophysical Institute during his visit to the University of Alaska's Fairbanks campus a few years ago.

I remember I was a little flustered by his surprise visit. He asked me in a very friendly manner what I was working on. Without time to recall that he was Joan's brother, I had to find the simplest way to describe magnetospheric physics to a physicist. I remember saying something like "a study of interaction between a supersonic plasma flow and a magnetized body, namely a magnetized planet with an atmosphere." He understood immediately what I meant.

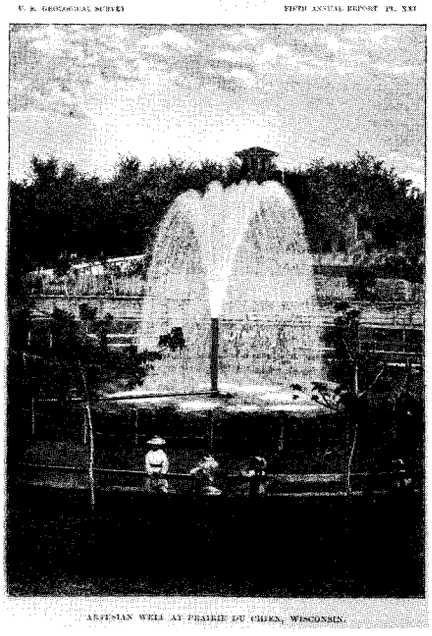
I found he had a personal interest in the aurora. He asked how such an interaction related to the aurora and we discussed how it could be a magnetohydrodynamic generator that powers the auroral discharge.

Then, surprisingly, he told me that he had always been interested in auroral physics and wanted to work on the solar wind-magnetosphere interaction. And, more surprisingly, he said he had to get permission from his sister Joan before he could embark on the project, because he had an agreement with her on such a matter.

Several years later I had an opportunity to read his autobiography, *Surely You're Joking, Mr. Feynman*, and recalled vividly his surprise visit. Now, hearing of his death, both are my precious memories of the great physicist.

S.-I. Akasofu
Geophysical Institute, University of Alaska, Fairbanks

WaterWatch



ARTESIAN WELL AT PRAIRIE DU CHIEN, WISCONSIN.

WaterWatch
News of the Hydrology Section.
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News & Announcements

IHP Council Meets

PAGE 1650

The Eighth Session of the Intergovernmental Council of the International Hydrological Program (IHP) was held June 21–25 in Paris. Gordon Young of Canada was elected chairman for the next 2 years. The council elected four vice chairmen: Mario C. Fuschini Mejia (Argentina), Riyadh Al-Dabbagh (Iraq), Umar Kawu (Nigeria), and Slavoljub Jovanovic (Yugoslavia). Anat Arbhabhirama (Thailand), as chairman of the previous council, is a member of the Bureau.

Of the 30 council members, 29 attended the meeting. Observers were present from 30 Unesco Member States not council members. The United Kingdom and United States also participated as observers under a ruling of the Unesco Executive Board. Other organizations represented were the African Union for Water Distribution, Arab Federation for Technical Education, Food and Agriculture Organization, Comite Interafricain de Etudes Hydraulique, International Association of Hydraulic Research, International Association of Hydrogeologists, International Association of Hydrologic Sciences, International Atomic Energy Agency, International Committee on Irrigation and Drainage, International Water Resources Association, Palestine Liberation Organization, and World Meteorological Organization.

The Unesco Director-General addressed the council. He noted that while Unesco must demonstrate leadership in science, the organization must do better with less. He stated that the Outline Plan for the Fourth Phase of IHP would form an integral part of Unesco's Third Medium Term Plan and noted that the recent session of Unesco's Executive Board had requested that the major intergovernmental scientific programs such as IHP be safeguarded. He concluded that he was convinced that in the years to come IHP would remain one of the pillars of Unesco action in rational management of natural resources to achieve sustainable development.

The council reviewed the status and plans for completion of IHP-III. The Secretariat presented documents and led the discussion theme by theme and project by project. The council notes that the success of the conclusion of the projects depends heavily on active participation of Member States in its implementation and on the importance of national programs related to IHP themes and the degree of adaptation in those programs to particular needs of each country. While satisfied with results so far, the council noted with concern the staff situation in the Secretariat and in particular in the Regional Offices for Science and Technology as a result of reduction in staff working for IHP. In a resolution the council urged "the Director-General of Unesco to ensure that adequate staffing is proficed for the satisfactory completion of the Third Phase of the International Hydrological Programme."

The future of the council's Committee on Education and Training was discussed. The question of the need for a Committee on Technology Transfer (to include Education and Training) was finally left to the bureau to decide. The Bureau subsequently did establish such a committee; it will meet before the Ninth Session of the council in March 1990 to review the educational activities of IHP-III, the planned activities for IHP-IV, and the proposed plan for developing a broad program of technology transfer during IHP-IV. Noting the essential elements of technology transfer, the council passed a second resolution urging "the Director-General of Unesco to ensure that appropriate funding and expert staff are provided to the IHP in order that this most important element of knowledge and technology transfer in the fields of hydrology and water resources be fully and adequately implemented."

In reviewing the draft plan of IHP-IV the participants agreed that the document was concise, had a definite logic, and reflected both development and environmental aspects. They agreed with the greater emphasis on technology transfer. After a lengthy discussion of the details of the themes and projects, during which the IHP-IV title was modofied to "Hydrology and Water Resources for Sustained Development in a Changing Enrironment," the council directed the Bureau to take into account the oral and previously submitted written comments in development of a final draft plan.

The Bureau subsequently developed a schedule for the preparation of the final draft plan by mid-1989. That draft will be submitted to the 25th General Conference of Unesco for approval and to the Member States for their review and commitment to implementation before the Ninth Session of the council. The council then passed a resolution recommending "that the General Conference of Unesco give full support to the planned fourth phase of the International Hydrological Programme and to the supporting water science activities and provide appropriate funding as well as adequate staffing at Headquarters and in the Regional Offices of Science and Technology for its full implementation."

This report is IHP information received from the Unesco Division of Water Sciences, Paris, France.